EOS Global Land Validation Network

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Abstract -- Although many approaches will be used to validate land products from the Earth Observing System (EOS), we describe the system being developed for the collection and comparison of field-measured parameters with EOS products. The most unique component is EOS Land Validation Core Sites, a global network of 24 high-intensity field measurement sites. These sites will provide the user community with the most timely and comprehensive ground, aircraft and satellite data available under EOS. Furthermore, data protocols and World Wide Web sites are being developed to promote public participation and long-term validation data preservation. Results of these validation activities will be conveyed to the community through both published literature and metadata embedded within product data sets.

INTRODUCTION

In July, 1999, NASA will launch the Terra platform, a keystone of its Earth Observing System (EOS). Terra's five instruments include highly evolved successors to current satellite sensors (e.g., MODIS vs. AVHRR) and innovative experimental sensors (e.g., MISR). Together, the many near real-time products (e.g., leaf area index (LAI)) from Terra will provide the most comprehensive view of the Earth system to date. Moreover, the co-aligned, calibrated sensors will present the best opportunity yet for validation of remote sensing products and algorithms.

Nevertheless, global validation of land remote sensing products is complicated by multiple factors, including difficulty in measuring land surface variables over the size of a satellite pixel, inherent errors in satellite data calibration, georegistration, cloud screening and atmospheric correction, and the impracticality and expense of collecting field data over a large number of different ground/atmosphere combinations over sufficiently long time scales. These constraints have therefore limited rigorous validation efforts to several "intensive field campaigns" (e.g., FIFE, BOREAS, HAPEX) where large teams were able to collect data over reasonably large areas during discrete phenological periods. While these efforts were necessary to show that various remote sensing algorithms were working correctly, they were not sufficient to truly validate a land product or algorithm, at least not for global, year-round application.

Despite these difficulties, the EOS Project has charged its instrument teams with both the development *and validation* of their operational products. In 1998, the Project augmented those efforts by funding 65 competitively-selected Validation Investigators. Approximately 44 of these will rely on *in situ* measurements and comparisons with EOS products. Thus, a close dialogue is developing among field data collectors, EOS algorithm developers, and the end-user community to ensure that the validation data are collected and packaged appropriately for greatest effectiveness. Particularly notable are the SWAMP Validation Workshop in 1997 [1] and a 1998 follow-up workshop for LAI and FPAR (canopy-absorbed radiation) validation [2].

APPROACH

Multiple validation techniques will be used to develop uncertainty information on EOS land products. The methods include comparisons with *in situ* data, comparisons with data from airborne and other spaceborne sensors (e.g., AVHRR, GOES), analysis of trends in products (e.g., spatial, temporal), and analysis of process model (e.g., climate model) results which are driven or constrained by EOS products. Successful validation will have been accomplished if timely and accurate product uncertainty information becomes routinely available to the product users within two years after Terra's launch.

VALIDATION SITES

EOS products will be generated operationally for all global land areas. Validation must therefore include attention to a wide range of combined surface cover and atmospheric conditions, from tundra to deserts to tropical jungles. Clearly, the costs associated with such a program can be tremendous. In an effort to contain costs, EOS will use a variant of the Global Hierarchical Observing Strategy [3], a multi-tiered categorization of field site measurement capabilities and intensity [4]. This categorization has an inverse number of sites in a tier relative to the measurement intensity per site. Thus, EOS will rely on few intensive field campaigns (e.g., LBA, SAFARI 2000) but on a large number of sites for which only high resolution satellite scenes are regularly available. In this article, we focus on two strata of the hierarchy: Core Sites and Product Sites.

Core Sites

EOS will concentrate much of its effort around EOS Land Validation Core Sites (Fig. 1). These 24 sites represent a consensus among the instrument teams and validation investigators and span a range of global biome types. The sites typically have a history of *in situ* and remote observations, and can expect long-term preservation. Each is nominally 100 km x 100 km in size. In most cases, a Core Site has a tower on which above-canopy instrumentation will be mounted to provide near-continuous sampling of landscape radiometric, energy flux and/or meteorological variables. Each site will also host a sunphotometer from NASA's AERONET Program for assessment of aerosol optical depth. Episodic sampling of more slowly changing land parameters (e.g., LAI) will compliment the ongoing measurements.

Significant effort has been placed on ensuring the early acquisition and open availability of relevant satellite data for Core Sites. Specifically, the ASTER and Landsat 7 teams have incorporated Core Sites into their priority scene acquisition plans, and arrangements have been made for independent archiving of ASTER, MISR, MODIS, CERES and MOPITT data. These data will be place in special archives within the EOS Data Active Archive Centers (DAACs), and be available through both traditional ordering systems and from unique Core Site WWW pages (Fig. 2). Limited historical AVHRR and Landsat TM data will also be available, and plans are being made to include EO-1 Hyperion data as well. The Core Site data archives will thus contain the richest and most diverse colocated data sets available through EOS. These benefits are expected to facilitate both validation and early EOS science.

Product Sites

EOS Product Sites will provide both diversity and redundancy to the Core Sites. In contrast to the Core Sites, a given Product Site may only be used to evaluate one EOS product [2]. The Land Cover Change, Land Surface Temperature, and Snow/Sea-ice products are sufficiently unique that their validation will occur primarily at Product, rather than Core, Sites.

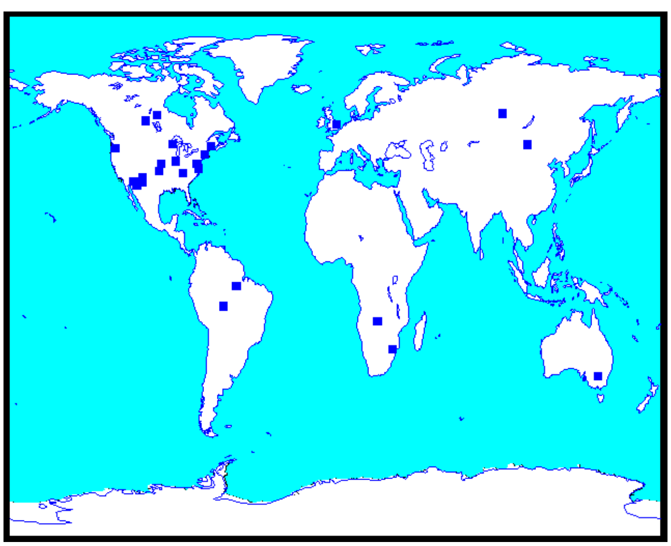

Fig. 1. Locations of EOS Land Validation Core Sites.

Despite these efforts, additional resources ckearly are needed for global validation than can be supplied by EOS alone. Thus, MODLAND has applied significant effort to developing EOS-wide validation protocols and encouraging the participation of community data collectors and product users. In particular, significant collaboration is planned with existing measurement networks, including FLUXNET, Long Term Ecological Research (LTER) sites, AERONET, and Global Land Cover Test Sites (GLTCS). In most cases, the EOS Core Sites are members of at least one of these networks. In addition, EOS is investigating the potential usefulness of other networks, such as BSRN and SurfRad.

SCALING

A pervasive problem for land validation is the scaling of field measurements to the more coarse resolution of satellite products. Although various schemes will be used, the newly begun BigFoot project will focus directly on EOS scaling issues. The BigFoot approach will include overlaying grids of 25 m and 1 km, extending to the 5 km x 5 km "MODIS grid," at FLUXNET tower sites. BigFoot will initially focus efforts at four EOS Core Sites. Investigators will measure and scale LAI, FPAR, net primary productivity (NPP) and landcover maps to appropriate resolutions for EOS validation. A combined program of field data collection, aircraft overflights and fine resolution satellite image acquisitions will be used. BigFoot will also attempt to characterize and parameterize the relationship between the measured net ecosystem exchange values and the NPP product. This pathfinding activity will test various scaling methodologies and work with MODLAND to develop a WWW site outlining a recommended strategy.

MODLAND QUICK AIRBORNE LOOKS (MQUALS)

To facilitate BigFoot's and others' scaling efforts, MODLAND developed the MODLAND Quick Airborne Looks (MQUALS). This program is based on an aircraft remote sensing package that includes three digital cameras (red, blue and near-infrared, 640x480 pixels), shortwave and near-infrared albedometers, a calibrated radiometer with four MODIS spectral bands, and an optional thermal radiometer. All data are simultaneously collected and stored on a laptop computer. A ground-based 4-band radiometer will be used to simultaneously measure irradiance. The complete package was designed to be shipped easily to small aircraft operators near validation sites for low cost site and reflectance characterization. Initial MQUALS products should be available within seven days of data collection. A duplicate MQUALS package will operate in southern Africa as part of SAFARI 2000. Within the greater EOS validation framework, MQUALS will be complimented by remote observations from sensors on NASA's high altitude ER-2 and a light aircraft package developed by the CERES team.

DATA PROTOCOLS AND DISSEMINATION

Successful validation will in part depend on easy access to accurate and documented field data. The MODIS Land Team has worked extensively with the Oak Ridge (ORNL) and EROS Data Center DAACs to develop validation data protocols and pathways. Based on distributed WWW mini-archives, the ORNL-based Mercury system will conduct daily data set cataloging and can provide single point access to all EOS validation data (Fig. 2). The minimal effort required to interface with Mercury should allow rapid data submission and public release. This evolving data system accommodates a diverse user community in which EOS instrument teams, Validation Investigators, and independent investigators are simultaneously collecting, archiving, distributing and using validation and remote sensing data. Moreover, the ORNL DAAC has initiated a vigorous effort to mine historical field data. These data will be used to establish expected values and reasonable ranges of EOS products in some cases.

CONCLUSIONS

We anticipate that the EOS Validation Program will act as a catalyst for broader involvement by the research community in EOS product evaluation. Clear protocols for data collection, WWW archiving will give all researchers a simple mechanism for participation. With the planned launch of many new moderate resolution sensors (e.g., VEGETATION, MODIS PM, GLI, POLDER, NPP/NPOESS VIIRS) and the increased availability of operational products, the benefits of standard measurement protocols and validation site data sharing are considerable. The Committee on Earth Observation Satellites (CEOS) Calibration/Validation Group is an obvious mechanism to expand the early developments and lessons learned in EOS's pilot land validation effort into a more comprehensive global validation program. Details of a prototype Core Site field campaign are described in [5] of these Proceedings. Further details are available at: http://modarch.gsfc.nasa.gov/MODIS/LAND/VAL/.

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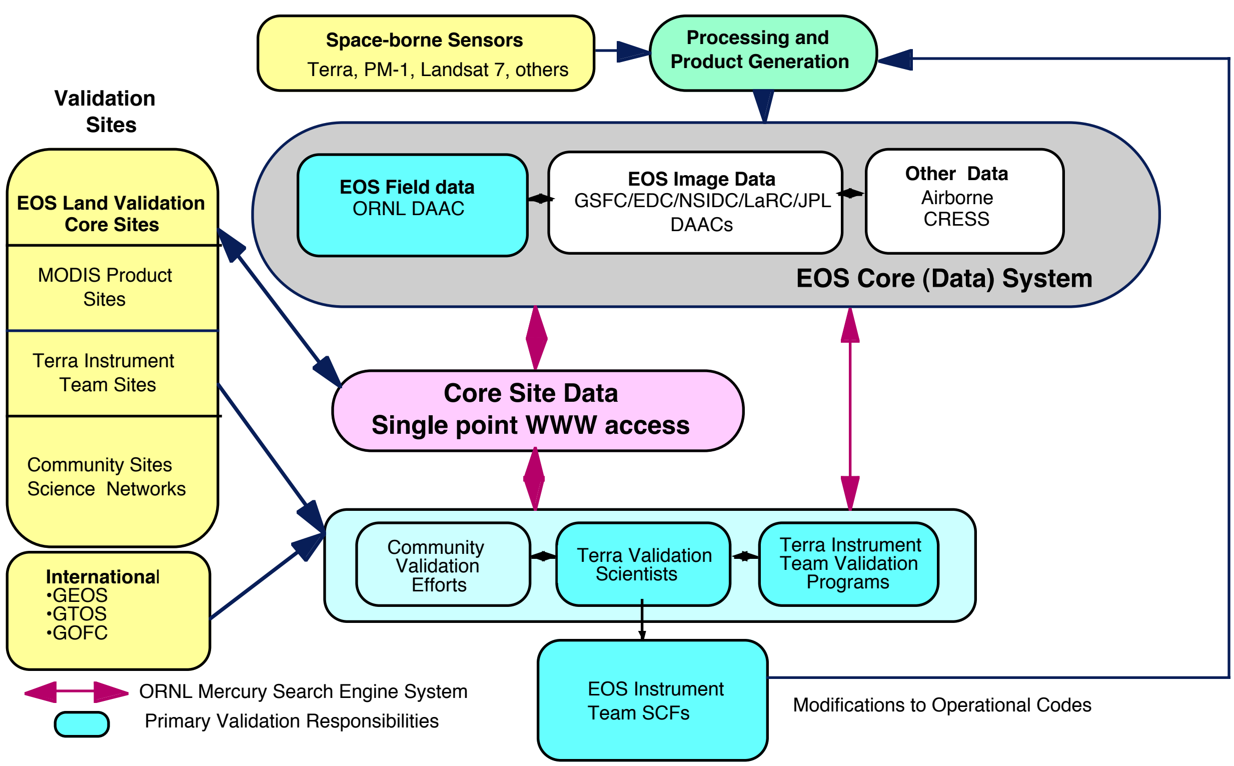

Fig. 2. Schematic of EOS validation data resources and pathways.